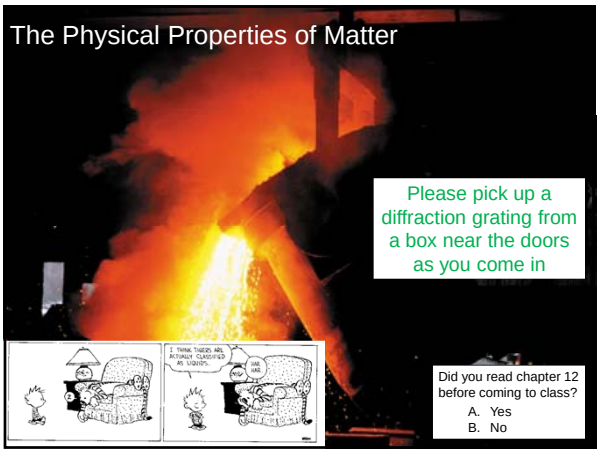
The Physical Properties of Matter



Where we are in the course

- Part I: How do things move?
  1. Newtonian View - the laws of force and motion
  2. Conservation laws
  3. Symmetry Principles
  4. Relativistic view
- Part II: What are things made of?

The First Model of Matter (Aristotle)

- 4 elements—
  - Earth
  - Water
  - Air
  - Fire
- Everything is made of a combination of these four things
- Not a great model, but it gets us started in the right direction: Classification

States of matter

- **Solid:** resists changes in size or shape, has a fixed volume

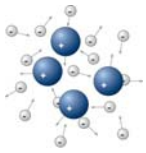


- **Liquid:** assumes the shape of its container but remains a fixed volume


- **Gas:** expands to fill shape and size of container

States of matter

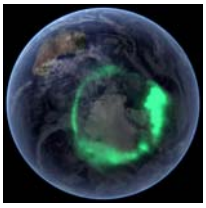
- **Plasma:** ionized gas; electrons become detached from atoms

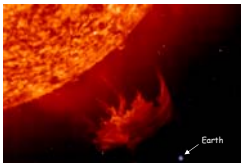





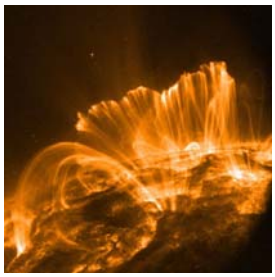
What is the most common state of matter in the visible universe?

a) Solid
b) Liquid
c) Gas
d) Plasma

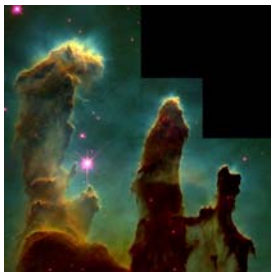




Over 99% of the visible universe is in the plasma state



Coronal Loops on the Sun (~250,000 miles long)

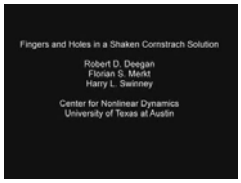


Eagle Nebula (Fingers are ~1 Light Year)

An Interesting Parallel

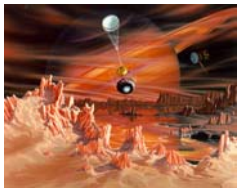
Modern	Ancient
Four **states** of matter	Four **elements** of matter
1. Solid	1. Earth
2. Liquid	2. Water
3. Gas	3. Air
4. Plasma	4. Fire

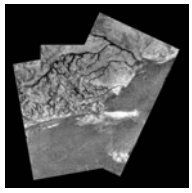
Some materials do not fit neatly into a state classification



The state of matter depend on temperature and other factors

- Example: Cassini-Huygens Titan Probe
  - Ammonia: Melts at -78 °C, boils at -33.5 °C





Changes of State

- State is a function of temperature (and pressure).
- Different materials change state at different temperatures.

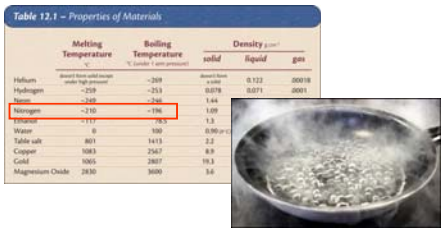


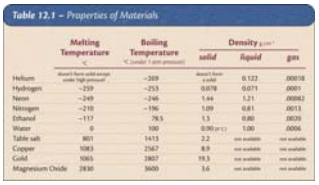
Table 12.1 – Properties of Materials

	Melting Temperature	Boiling Temperature	Density solid	Density liquid	Density gas
Helium		−269		0.122	.00018
Hydrogen	−259	−253	0.078	0.071	.0001
Neon	−249	−246	1.44	1.21	.00082
Nitrogen	−210	−196	1.09	0.81	.0013
Ethanol	−117	78.5	1.3	0.80	.0020
Water	0	100	0.90	1.00	.0006
Table salt	801	1413	2.2		
Copper	1083	2567	8.9		
Gold	1065	2807	19.3		
Magnesium Oxide	2830	3600	3.6		

Balloon in liquid Nitrogen: air phase change

An unknown solid melts at -50 degrees into a clear liquid that looks similar to water and ethanol. Which of the following would most likely be its boiling point?

A. -120 degrees
B. 0 degrees
C. 90 degrees
D. 1,000 degrees



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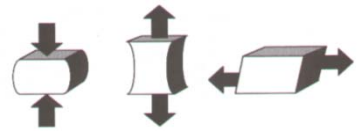
The temperatures at which substance transform from solid to liquid and liquid to gas give information about the strength of the bonds holding the material together.

Response to forces that deform



Which forces do
- **Solids** resist?
- **Liquids** resist?
- **Gases** resist?

Deformation

- Elastic deformation: object returns to its original shape after the deforming force is removed.
- Plastic deformation: object retains its new shape when the force is removed.
- Elastic limit: transition point between elastic and plastic deformation for a material.

Demo: Elastic properties and temperature

- Rubber Nail
- Marshmallow
- Rubber Band
- Fingernail
- Penny

The color of an object gives information about its composition

- The color of an object is determined by what wavelengths of light it reflects (or emits)
  - Examples: Tomatoes reflect red light, and absorb other colors.
  - Clover reflects green colors, absorbs others

The spectrum of light source is a measure of which wavelengths are present

- **continuous spectrum**

- **discrete spectrum** -- only a few specific colors

- Discrete absorption spectrum – All colors but a few lines

Why is the sky blue?

- Sunlight contains a continuous spectrum of all visible colors
- Short wavelength (blue) light is more easily scattered to the side by air molecules than long wavelength (red) light.
- The sun is red in the evening because the light travels through more atmosphere, and more of the blue light is scattered to the side before it gets to you.

Conductivity Demo

- steel
- sugar
- salt
- water
- solutions

Electrical Conductivity

- **Conductor** - electric current flows easily
- **Nonconductor** - resists flow of current (insulator)
- **Semiconductors** - allow current under special conditions
- **Ionic materials** - nonconductors that become conductors when liquid or dissolved in water
- **Nonionic** - nonconductor when liquid or dissolved in water

Density

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

steel

Styrofoam

- Objects normally contract when cooled. What happens to the density? Why?
- Water is an exception. It expands as it changes to a solid, so ice is less dense than liquid water
  - This is good; Otherwise ice would sink and the planet would freeze over.

A ball bearing and a cannonball are made of the same material.

a) The cannonball will be more dense than the bearing
b) The two objects will have the same density
c) The bearing will be more dense than the cannonball

Summary

- We classify matter according to
  - State (solid, liquid, gas, plasma)
  - Color
  - Response to force (deformation)
  - Density
  - Conductivity
- Over the next several lectures we will discuss various models that have been used to explain the origin of these properties.